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MONTHLY PROGRESS REPORT

FOR

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INDOOR ENVIRONMENT DEPARTMENT

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Notice

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INDOOR ENVIRONMENT DEPARTMENT

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1. Energy Performance of Buildings

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A. Infiltration, Ventilation, Indoor Air Quality
Sponsor(s): DOE-EE
Collaborator(s): University of Alberta

Background
Using between 2-4 Quads of energy, infiltration is a major energy expense in existing envelope-dominated buildings. Much of this project is devoted to the characterization and optimization of infiltration in small buildings. Model development, instrumentation design, test methods, analysis and stock characterization are all continuing pieces of the work in this area. Understanding the impacts of infiltration and ventilation for both energy and indoor air quality is done through modeling and measurement. Combined heat and mass transport modeling (e.g. in the infiltration heat recovery project) is necessary to accurately determine energy use and potential retrofits.

In new construction, infiltration is much less and does not normally provide sufficient ventilation for acceptable indoor air quality. Accordingly this project supports ventilation standards through scientific research and also participation in consensus standards and code support. Max Sherman is chair of ASHRAE's Residential Ventilation standard (62.2P) and also serves on the non-residential standard. Data collection and analysis of air tightness of new construction is currently in progress.

Technology transfer and implementation support activities to state, federal, and international groups is a continuing effort. LBNL represents the US at Annex V of the IEA/ECBCS project, the Air Infiltration Centre. LBNL staff strongly support ASHRAE, ASTM and other consensus activities as well as assisting others in program and code development. Scientific and popular articles are also used to assist users in making use of DOE-funded research.

February 2001
Converting the infiltration heat recovery simulation from Fluent to StarCD continues to go slowly and has delayed progress on this task. Detailed investigations into the CFD simulations have provided some potential physical insights into the role of boundary layers in putative infiltration heat recovery. The phase-up of StarCD simulations has been organized so as to investigate this phenomenon in some detail. Depending on the outcome of the these investigation, either an independent recovery mechanism will be resolved or an effective calculational short cut will have been found.

ASHRAE's proposed residential ventilation standard generated a lot of interest at ASHRAE's Winter meeting in Atlanta this January, which resulted in extensive follow-on activities. The 3000 commentors on standard 62.2P were invited to a comment resolution meeting to hear the committee's rationale and to discuss their concerns in an attempt to improve the consensus. Although the vast majority of unique comments were resolved at some level, the committee, chaired by Max Sherman, felt that inviting unresolved commentors would improve the document and the consensus prior to a second public review.

The committee made some changes to the draft as a result of discussions held at the meeting; the changes were of three types: 1) wording changes that clarified the standard or improved usability but did not change the intent; 2) changes which dealt with specific requirements for special cases; and 3) changes which represented a real change in requirement. After these changes were made the committee voted to recommend the revised draft for public review.

The draft standard now has the following key requirements:
* Whole-house mechanical ventilation of about 50 cfm (25 l/s) for a typical new house. (Older homes may offset this with an additional infiltration credit in some cases.)
* Local exhaust ventilation in bathrooms and rooms with unvented combustion equipment. (If the uncompensated exhaust capacity is too large, naturally aspirated combustion equipment inside the pressure boundary must be tested for backdrafting.)
* Medium efficiency particle filtration for most air handling systems. (Air handling systems must also be isolated from garage pollutants.)
* Minimum specifications for ventilation fans including delivered air flow, noise, re-entrainment and branching.
* Windows: most rooms must have operable windows (or some other means) to allow occupants to provide local ventilation to account for unusual sources.

The changes made at the SPC 62.2P meetings in November and January have resolved most of the issues raised in the public review. Implicitly, the committee feels that a true consensus has been reached within ASHRAE and, accordingly, forwarded the standard up the line with a recommendation for a second public review.

Even though the committee reached consensus there were two key issues that disturbed two interested parties. Although some of NAHB's comments were resolved, their key concern of requiring mechanical ventilation was not. The committee almost unanimously believes the data that shows that acceptable indoor air quality cannot be achieved in typical new construction without the use of mechanical ventilation.

The natural gas industry submitted a lot of constructive comments to the first public review and in subsequent meetings. Most of their concerns were, in fact, resolved with the exception of one narrow one. The Gas Appliance Manufacturers Association

(GAMA) objects to requirement that exhaust ventilation is required in any room in which an unvented combustion device is used.

To be approved for a second public review, the Board Policy Committee on Standards (BPCS) must approve a High Profile Standard (HPS) such as 62.2P. When they considered approving the second public review, both NAHB and GAMA presented their objections to BPCS, who then did not approve the second public review. The committee is currently undertaking activities to attempt to resolve the BPCS objections.

B. Residential Envelopes and Commissioning

PIER Residential Commissioning Project
Sponsor(s): DOE, California Energy Commission (CEC)
Collaborator(s): None

Background
Currently, houses do not perform optimally or even as many codes and forecasts predict, largely because they are field assembled and there is no consistent process to identify deficiencies or to correct them. As a step toward alleviating this problem, the Public Interest Energy Research (PIER) program of the California Energy Commission (CEC) is funding our research project to lay the groundwork for a residential commissioning industry in California. The vision is that this industry will focus on providing end-use energy and non-energy performance assurances for new and existing houses.

To accomplish the goals of this 30 month-long project, which began in September 1999, scientific research methods are being used, with oversight by industry stakeholders and the CEC. These methods include field data collection, laboratory measurements, simulation, and analysis of existing and newly acquired information. We have already completed and published a literature review of existing information on commissioning. We are now midway through our study of metrics, diagnostics, and norms to ascertain what potential benefits one can realistically expect from residential commissioning. By the end of this year, we will begin to write one or more commissioning guides to allow non-experts to achieve these benefits. Project results will also be disseminated through various industry meetings and publications.

February 2001
This month, we prepared and submitted an outline of the commissioning guide that we will develop over the next nine months. At the CEC's request, we also prepared and submitted a separate list of diagnostics that we had evaluated during the project, but that we have excluded from the guidelines because they are inappropriate for commissioning or are not ready to be used.

Work continued on our potential value study. Definitions of simulation cases and assumptions for modeling whole-house energy consumption and peak demand are complete and simulations are in progress. The cases include three house types: an existing 1950-1970 non-retrofitted house, a house that meets current California Title 24 requirements, and a house that represents current Building America practice. We are modeling these houses using four California locations: Sacramento, Fresno, Pasadena, and El Toro. The first two represent inland climates; the latter two represent coastal-inland transitional climates. For each house-climate combination, we are simulating three cases. One is a base case representing an uncommissioned "as found" house. The second is a "tuned" case representing a house with envelope and HVAC system improvements made during a commissioning visit (e.g. duct sealing). The third is an "opportunity" case representing the addition of more time-consuming improvements that incorporate opportunities identified during the commissioning visit (e.g. installing wall insulation or a replacement cooling system in an existing house). We are carrying out the simulations using DOE-2, supplemented with externally-calculated hour-by-hour combined infiltration and mechanical ventilation rates and externally-calculated seasonal duct efficiencies. To support the simulations, we developed DOE-2 transfer function inputs this month to represent imperfect envelope assemblies with insulation anomalies such as edge gaps or void spaces.

We prepared for and attended the second Critical Project Review meeting with the CEC in Sacramento. Discussions at that meeting included the status of our work to date, as well as a review of our outline for the commissioning guide. The CEC is pleased with our work so far. Based on this review, we expect to receive written approval from the CEC Contract Manager in early March 2001 to continue work on the project.

Work to disseminate project results has continued. This month, we completed our paper for the December 2001 Performance of Exterior Envelopes of Whole Buildings VIII conference. The paper is entitled "Residential Commissioning to Assess Envelope and HVAC System Performance". It describes a consolidated set of practical diagnostics that can be used now to commission envelope and HVAC system performance. In particular, it discusses the accuracy and usability of available diagnostics, based on recent laboratory work and field studies. It also describes areas in need of research and development, such as practical field diagnostics for envelope thermal conductance and combustion safety. We expect internal review of the paper will be complete in early March.

Work also continued in preparing a second commissioning-related paper. It is entitled "An Evaluation of Refrigerant Charge Diagnostics for Commissioning Residential Cooling Systems". The paper will describe the available diagnostic technologies, their accuracy, their utility for contractors, and the barriers to using them. It will include results from our laboratory and field tests last fall. Of particular note, our field and laboratory data indicate that a 10º F superheat error or more can easily occur in a refrigerant superheat test. Sources of error include refrigerant pressure gauge

inaccuracies, incorrect temperature measurement locations, direct sunlight on unshielded temperature sensors, and using an improperly insulated temperature sensor that has poor surface contact with the refrigerant line. We are conducting further analyses of air conditioner test data from the Energy Systems Laboratory of Texas A&M University to determine the impact that these temperature and pressure measurement problems have on charge assessment using superheat tests.

We completed our work this month on an indirectly related white paper, which we prepared as part of an Environmental Energy Technologies Division collaborative effort. It is entitled "Demand-Responsive Building Systems as a Resource for Electricity Reliability". The paper describes a short-, medium-, and long-term research agenda, along with several strategies and technologies to reduce peak demand. Of particular note, it describes commissioning issues related to reducing the peak energy demand of new and existing houses. In the California buildings sector, residential cooling is the largest single contributor to peak demand.

This month, we requested a student for Summer 2001 through the DOE Energy Research Undergraduate Laboratory Fellowship (ERULF) program. Our plans are to have the student participate in multizone airflow and contaminant transport studies of the indoor air quality benefits of continuous ventilation. In these studies, the student's role will be to assist in analyses and interpretation of field data that we are collecting now in a Fresno house, and to carry out simulation-based evaluations of various ventilation strategies.

C. Residential Distribution and HVAC Systems

Thermal Distribution System Figures of Merit
Sponsor(s): DOE, CIEE
Collaborator(s): None

Background

Forced air thermal distribution systems in residences typically lose about 30% of the energy they consume. Because this is a large fraction of the energy consumed by the HVAC system, it is important to be able to provide good estimates of thermal distribution system efficiency. To accomplish this we are developing an ASHRAE Standard to determine the distribution system efficiency of forced air (and hydronic and electric) systems. Also, we have developed sophisticated forced air distribution system computer simulations that are being used to identify potential duct system improvements. These figures of merit are already being used by several authorities (e.g. California Energy Commission and Environmental Protection Agency).

February 2001

We have written an updated draft of our thermal distribution webpage to include the effects of duct insulation on duct system performance. We have begun to look at using

the draft ASHRAE Standard 152P calculation method to examine the interactions between multiple speed/capacity equipment and their thermal distribution systems. Specifically we are investigating the reductions in duct system efficiency when system air flows and capacities are reduced, and how this decrease in duct efficiency may offset increases in part-load equipment performance.

The draft ASTM Duct Leakage standard that includes the DeltaQ test was balloted by ASTM this month.

Planning continued this month regarding future longevity testing. The consensus is that we still need to test some common duct connections: duct board splitter boxes and round-to-round sheet metal with three wraps of cloth duct tape. We are currently waiting for the splitter box samples to arrive for testing. A new draft of the ASTM Duct Sealant Longevity standard was balloted this month by ASTM.

A new draft of ASHRAE Standard 152P was completed this month, in preparation for public review by ASHRAE. This draft includes all the responses to comments from the first public review as well as numerous changes proposed by the committee. Some of the key changes include the use of different weather data for seasonal conditions and changed measurement procedures in addition to many small editorial changes. Next month, we plan to have this draft will be letter balloted by the standard 152 committee.

Distribution System Measurements
Sponsor(s): CIEE, DOE
Collaborator(s): Richard Heath & Associates, CA State University-Chico

Background
Estimates of residential HVAC system performance require measurements of several characteristic parameters. We are writing standard test procedures (through ASHRAE and ASTM) for the building industry to use. This includes development of new test procedures (e.g., the DeltaQ test for residential duct leakage) and evaluation and improvement of existing procedures. Both field and laboratory testing are being used to identify key aspects of distribution system performance so that these systems can be improved in both new construction and retrofits of existing buildings. The field measurements give a baseline for estimating peak demand and energy consumption. The laboratory measurements allow development of test procedures and equipment under controlled conditions.

February 2001
We are continuing to perform detailed analysis of the DeltaQ test method and results based on the over 100 tests performed in conjunction with CSUC and the tests that EPB has done. In addition to looking at more sophisticated analyses that may eliminate the need to measure plenum pressures during the test we are also looking at adapting the DeltaQ approach to estimate air handler flows.

Field testing of a house in Fresno, CA, started this month. This house is being continuously monitored for several weeks to determine duct system losses due to continuous air handler fan operation. In addition, the individual room-by-room measurements of air temperature and delivered energy (at each register) will be used to evaluate how well the thermal distribution system serves individual rooms. Both of these issues will potentially be included in future versions of ASHRAE Standard 152P. The diagnostic measurements made so far have characterized the building and its HVAC equipment. A data acquisition system was installed to continuously monitor the building and HVAC system energy performance by measuring ventilation air flows, temperatures in the house and HVAC system and weather conditions. The HVAC system is being operated in two modes. In the first mode, the air handler runs continuously and in the second mode, the sir handler cycles with furnace operation. We are alternately operating the house in these two modes a few days at a time so that we can have results for similar weather and house conditions for both modes. Data from this system is being downloaded daily as a check on the system status.

Laboratory testing of flexible plastic ducts and duct fitting losses was performed this month. This work is determining the losses associated with many fittings commonly found in residential duct systems that are not currently included in many design methods. This includes testing the losses for flexible plastic duct in several configurations: stretched tight, normal, compressed and for several bend angles. Initial analysis shows that the pressure drops in plastic flex duct that is sharply bent, or not stretched out are high and will certainly be a significant contribution to low air flow rates in residential systems. These tests were performed over a large range of flows and for several duct diameters. When these tests are complete we will be able to produce standardized data sheets for use in system design calculations. In addition, we have begun the construction of a full scale residential HVAC system for laboratory testing of measurement methods and duct system pressure losses.

The laboratory testing of coil fouling continued this month together with development of some simplified analytical models of deposition. We have largely perfected the extraction of the leading edge of the coil separate from the rest of the coil. The results show that there is less deposition on the leading edge relative to the rest of the fins than expected. An explanation we are investigating is that the fins are not continuous, but instead have many "leading edges" throughout the coil. This leads to increased deposition by impaction as well as deposition by impaction on places other than the leading edge of the coil. We are continuing to investigate this issue. We have almost completed the initial set of experiments and analysis of the results is continuing. We have begun the planning of the next phase of experiments to include solid particles and a cooled coil.

Innovative Duct Technology
Sponsor(s): DOE

Collaborator(s): PEG

Background

This DOE STTR is developing a new forced air duct system that uses simple snap together fittings that eliminate duct leakage and many duct system installation problems. Our contribution to this work is to perform field and laboratory testing of the new duct assemblies and to provide commentary and assistance in development of the final design.

February 2001

This month we began the ordering process for construction of the duct connection prototypes. These prototypes are being built to a specification determined by Proctor Engineering Group and Cornerstone Design (who will build the prototypes).

D. Commercial Distribution and HVAC Systems

Performance Characterization of Thermal Energy Distribution Systems in Commercial Buildings

Sponsor(s): DOE-EE, CEC

Collaborator(s): None

Background

The DOE project goal is to obtain the knowledge about system performance of thermal distribution systems in light commercial buildings in non-sunbelt regions, i.e., outside of California. This is in companion with the CEC-funded project on the metrics development for the performance characterization of commercial thermal-energy-distribution systems. The objective of the CEC-funded project is to create useful scientific data and test methods to facilitate better design and evaluation of the energy and environmental performance of thermal distribution systems within light commercial buildings (floor area between 2,000-10,000 ft2) and large commercial buildings (floor area over 10,000 ft2).

February 2001

This month, we communicated with a number of building contacts to solicit building systems for field studies on duct system characterization and aerosol sealing. Based on drafted documents on metrics, diagnostics methods, test plans, and building system criteria, we started to schedule on-site visits to buildings and conducted an on-site visit to a large medical office building from which we have got permission. The owner reports that the ducts in this large VAV system are probably very leaky and he is interested in having us to do some characterization tests and possibly sealing the ducts pending on mutual agreements. Although this building is not the first choice for our pre and post duct retrofit study, it at least offers a decent opportunity for our characterization study. We will continue to pay on-site visits to some other buildings about which we are in talk with interested parties. After phoning Wisconsin Energy

Center (WEC) a number of times, we have not heard back directly from Abby Vogen, the contact person at WEC; however, we did hear from Pacific Energy Center that Abby Vogen is working on obtaining buildings for us in Wisconsin and will get back to us later.

Development and Testing of Aerosol Sealing Technologies
Sponsor(s): DOE-EE
Collaborator(s): None

Background
This project is developing and evaluating aerosol-based sealing techniques that could be used in large duct systems.

February 2001
We built a new duct section for testing the pressure drop, which is impacted by aerosol sealant deposition on duct walls. The plan on upcoming tests was drafted. We tested the sealant injection by using a Schilick nozzle. The injection was into a plastic tubing with the diameter of ten-inch. Results showed that the Schilick nozzle created spray pattern that was much narrower than those created by our previous ones, and that it could discharge non-diluted sealant well.

Donatien Dumontier, a French student, joined our group this month to assist in the commercial projects. He will be working for approximately four months and is expected to do laboratory experiments on compact injector development as well as field test when needed.

OUTSIDE CONTACTS
Craig Wray continued to participate in conference calls on how the LEED-R Green Building Rating System that is now under development can incorporate residential commissioning.

Iain Walker attended a PIER Technical Advisory Group meeting at GARD Analytics in Oakland to provide technical advice on residential duct systems and backdrafting of naturally vented gas appliances.

T. Xu sent out a reminder to Project Advisory Committee (PAC) requesting for their critical review comments. We expected to hear comments from PAC members in March to be incorporated into revision version.

T. Xu talked to a number of outside contacts to arrange on-site building visits.

M. Modera gave a technical presentation for the ASHRAE Chapter of Sacramento at SMUD, CA. He conducted a survey on commercial buildings and duct-systems, which

was designed by T. Xu, among the participants. Results of the event are being used for more building solicitations.

M. Modera attended the ACCA trade show in Las Vegas, NV.

INDOOR ENVIRONMENT DEPARTMENT

2. Ventilation and IAQ Control Technologies

W.J. Fisk, A.J. Gadgil, R.G. Sextro, A.T. Hodgson
510-486-5910

A. Ventilation Measurement Methods

Measuring Outside Air Flow in AHUs
Sponsor(s): DOE-EE
Collaborator(s): none

Background
Current ventilation data indicate that there are wide variations in ventilation rates among buildings. In many buildings, minimum ventilation rates are well below or above the rates in applicable standards. These data and our research experience demonstrate that the common methods of measuring and controlling the rate of outside air supply by air handlers are often inadequate. The consequence is poor air quality in some buildings and excessive ventilation rates in other buildings. Starting in the middle of FY 2000, we initiated a new research effort on methods of monitoring and controlling rates of outside air supply by air handling systems. The work plan is broken into five categories:

- Communication with industry (ongoing throughout the project)
- Literature / hardware review and Common Practice Survey
- Controlled rooftop (or laboratory) experimental evaluation of technologies
- Field studies (small effort before and larger effort after controlled experiments)
- Work with a professional organization to develop performance testing protocols

February 2001
Woody Delp continued to assemble and review papers for the review of outside air measurement techniques. He also started to assemble a database of available hardware products.

B. VOC Sources, Emissions, and Controls

Modeling Emissions of VOCs from Indoor Materials
Sponsor(s): DOE-EE
Collaborator(s): Virginia Tech

Background
Al Hodgson is working in collaboration with professor John Little and graduate students Steve Cox and Deept Kumar of Virginia Tech (VT), Blacksburg, VA to produce mechanistic models that describe the emissions of volatile organic compounds (VOCs)

from various solid materials used in buildings. The primary objectives of this research are to better understand and to be able to predict the impact of VOC sources and sinks in the indoor environment. An ancillary goal is to create a less-expensive and superior alternative to emissions testing in environmental chambers for estimating VOC emission rates from building materials. This effort has recently resulted in the development and validation of a physical model for predicting the rate at which VOCs are emitted from vinyl flooring, an exemplary solid-phase material. The key model parameters are the initial concentration of a VOC in the material phase, the VOC material/air partition coefficient and the VOC material-phase diffusion coefficient. These parameters are independently measured using novel methods developed as part of this project. The research collaboration is now attempting to extend the physical model to predict VOC emissions for simple bi-layered materials.

February 2001

Reviewers' comments from the Journal of Air & Waste Management Association were received for the manuscript, "Measuring Concentrations of Volatile Organic Compounds in Vinyl Flooring." Most of these comments have been addressed. Internal reviewers' comments were received for the manuscript, "Predicting the Emission Rate of Volatile Organic Compounds from Vinyl Flooring." We made a number of revisions in response to these comments. A manuscript entitled, "Effect of Air Exchange Rate on Emissions of VOCs from Building Materials," is being prepared for presentation at the 2001 Annual Conference of the Air & Waste Management Association.

Impacts of Ventilation Rate on VOC Concentrations and Emission Rates

Sponsor(s): DOE-EE

Collaborator(s): U.C. Berkeley, Center for the Built Environment

Background

A ventilation-rate intervention study (section 3A) is being conducted to quantify the relationships of worker performance in a call center with ventilation rate and air temperature. The three-month study period was concluded in October. The building's air handling systems were operated at three constant outside-air supply rates. The minimum rate corresponded to applicable code requirements. Ventilation rates were periodically changed over 12 weeks. The schedule incorporated both weekly and daily adjustments of the outside air damper settings. Building temperatures, relative humidities, CO_2 concentrations, and airflow rates in the air handling systems were monitored and recorded. The research team is using the opportunity provided by this intervention study to quantify the effects of building ventilation rate on the concentrations and source strengths of VOCs, including formaldehyde. Air samples for VOCs were collected from outdoor air and the four building air returns on a single mid-week day during seven weeks. The air samples were qualitatively analyzed to identify the predominant compounds present in the building. A suite of 50 compounds was

quantitatively analyzed. Measured airflow rates are being used to calculate VOC emission rates for the four air handler zones.

February 2001
A principal components analysis was conducted for a set of 13 target VOCs with indoor sources. Calculated emission rate data were used as inputs. The analysis revealed four significant factors. The first factor, which accounts for more than 50% of the variance contained oxidized solvents and is probably associated with office cleaning products.

Comfort and Health-Based Guidelines for Indoor Concentrations and Material Emissions of VOCs
Sponsor(s): DOE-EE
Collaborator(s): Building Ecology Research Group, Health Effects Institute

Background
The overall goal of this project is to develop a methodology for establishing comfort and health-based guidelines for indoor concentrations and material emissions of VOCs. Hal Levin of the Building Ecology Research Group, Santa Cruz, CA and J. Ten Brinke of the Health Effects Institute, Cambridge, MA, are collaborating with A. Hodgson on this effort. A database has been developed that contains approximately 90 individual VOCs spanning a broad range of volatility and chemical functionality. Most of these compounds have been detected in North American houses and office buildings. Available data for the 90 compounds on occupational inhalation exposure guidelines, sensory irritation measured by mouse bioassay, odor thresholds, and chronic reference exposure levels established by the State of California have been summarized from the literature and incorporated into the database. A methodology for evaluating the potential for a compound to elicit a comfort or health-based response among building occupants is currently being evaluated.

February 2001
There was no activity on this task in February.

Joint Research and Demo Project on Energy Efficient and Healthy Homes
Sponsor(s): DOE-EE
Collaborator(s): Florida Solar Energy Center

Background
A primary objective of this research is to determine the sources and entry pathways of the most abundant and persistent VOCs in new houses, including houses with energy-efficient features. A. Hodgson, in collaboration with Subrato Chandra and David Beal of the Florida Solar Energy Center (FSEC), Cocoa, FL, is currently conducting a field and laboratory study to identify and quantify the sources of terpene hydrocarbons, formaldehyde, other aldehydes and carboxylic acids in a new manufactured house. The house is located in Florida and is used daily as a sales model. The manufacturer

supplied a detailed list of all of the materials used in construction of the house. Specimens of the major materials were obtained from the production facility. Laboratory chamber tests were conducted with these materials to measure the emission rates of the target VOCs. These emission rates were used with the material quantities to estimate whole-house emission rates. The predicted emission rates were compared to emission rates calculated from the measured ventilation rates and the concentrations of VOCs in the house approximately four months after its completion. For 11 of 14 predominant compounds, the predicted concentrations agreed within a factor of two.

February 2001

We completed the evaluation the effectiveness of various vapor barriers for reducing the emissions of aldehydes and other VOCs from plywood subfloors under carpet systems. Three water-based sealers, including one acrylic and two polyurethane finishes were evaluated in the laboratory using conditioned plywood as a substrate. All three of these finishes produced elevated emissions of various glycol ether solvents seven days after they were applied. In addition, they did not substantially reduce the emissions of hexanal, the predominant aldehyde emitted by plywood relative to the control. Thus, such finishes are not considered to be a desirable or an effective method for sealing plywood. Vapor barrier materials such as perforated aluminum foil, non-woven fiber and carpet cushions with an integral vapor barrier appear to be the best choices for use over plywood subfloors in residences to reduce the emissions of formaldehyde, hexanal and other aldehydes.

C. Ventilation and Indoor Air Quality Studies

Assessment of Particle Control Technologies

Sponsor(s): DOE-EE

Collaborator(s): Helsinki University of Technology

Background

The objectives of this effort are to quantify the reductions in indoor concentrations of particles, from various sources, that result when a variety of air cleaning measures are employed, and to characterize the associated energy costs and total costs. This work is based on analyses of existing data and modeling. The sources of particles considered are outdoor air (fine mode), dust mites, cats, environmental tobacco smoke, and droplet nuclei from coughs and sneezes. The particle air cleaning options include filtration, with various filter efficiencies, and electronic air cleaning. We are evaluating air-cleaning equipment installed within HVAC systems and stand-alone devices.

February 2001

Preparation of the draft paper continued. Methods of estimating energy and total life-cycle costs were described in the methods section. The section of results on reductions in particle concentrations was also written.

Task Ventilation Optimization
Sponsor(s): DOE-EE
Collaborator(s): none

Background
In prior years, we have investigated the ability of several task ventilation systems to provide better ventilation, and reduced pollutant levels, at the breathing zone, relative to conventional ventilation systems with well-mixed indoor air. The results of the most recent set of experiments were quite promising. All of the commercially available task ventilation systems have been designed to provide local control of thermal comfort. Improved ventilation at the breathing zone has been an incidental feature of these systems. Starting in the second half of FY2000, we initiated experiments and modeling to optimize ventilation performance. Rather than evaluate commercial products that have not been optimized for ventilation performance, we will design and evaluate new technologies for supplying air near the occupant. As of the end of FY2000, an initial set of parametric studies had been completed to provide qualitative visual images of the airflow patterns between the task ventilation system's air outlet and the breathing zone of a heated mannequin. We also started developing the software for computation fluid dynamics (CFD) modeling of these systems. A post doctoral fellow, Seung Min Lee, started working on this effort during September 2000.

February 2001
Preliminary tracer measurements were completed to determine optimal settings for the mass spectrometer and guide the selection of sample locations. Preliminary air velocity measurements around the heated mannequin were also completed. A new more flexible air supply nozzle is being fabricated. The chilled water supply to the laboratory was re-plumbed to enable more reliable control of room air temperature.

HyPak Project
Sponsor(s): Davis Energy Group
Collaborator(s): LBNL Building Technologies Department, Davis Energy Group, Des Champs Laboratories, Arthur D. Little

Background:
The Davis Energy Group as prime contractor received an award from NETL to develop an Hydronic Packaged Rooftop Unit (HyPak) that replaces conventional rooftop packaged units but saves energy and improves indoor air quality. The Hypak is designed primarily for climates with a low or moderate humidity. The IED's role in this project is to devise the technology for real-time integrated measurements of the rate of outside air supply, to select the filtration option, and to contribute to a field study of the units IAQ performance.

February 2001

A model was developed to enable prediction of airflow rates in the HyPak unit as a function of the leakage area and exhaust flow rates from the space served. Initial simulations have considered a system with a multi-speed fan for the ventilation air supply. In addition, as part of our effort to select a filtration system we are examining the HyPak pressure budgets and reviewing filter data.

D. Indoor Environmental Quality and Energy Efficiency in Relocatable Classrooms

Improving IAQ and Saving Energy in Relocatable Classrooms
Sponsor(s): California Energy Commission
Collaborator(s): Davis Energy Group, Pacific Gas and Electric Company

Background

In this study, Element 6 of the California Energy Commission (CEC) funded High Performance Commercial Buildings Systems Program, we will investigate and demonstrate how the application of building science and ventilation engineering can lead to simultaneous building energy savings and indoor environmental quality performance improvements. This project focuses on developing and testing a concept for high-performance relocatable classrooms (RCs). RCs, otherwise known as "School Portables," or "Modular Classrooms," are very common in California. RCs provide school districts with quick and convenient means of adding or replacing classrooms. RCs can be moved around, reducing unnecessary classroom construction. Currently the State of California mandates that at least 20% of new classrooms be RCs.

In this project we will evaluate the benefits of a novel building ventilation system and also of selecting construction materials that emit fewer indoor pollutants. We will construct and study three or four RCs sited in California school districts. One project will test a high-performance ventilation and air conditioning system, the Indirect-Direct Evaporative Cooler (IDEC), suitable for warm dry climate zones of California. In these climates, IDEC offers potential cooling energy savings of about 70% compared to the standard (10 SEER) air conditioner used in RCs. In addition to energy savings the IDEC provides a continuous flow of outside air that will improve the indoor air quality of the RCs. For heating, an energy-efficient natural gas-powered hydronic loop will be integrated into the IDEC ducting system. A second project will focus on identifying RC materials that are VOC sources through chamber measurements in RCs. Two RCs tested in the field will be constructed using materials selected for lower VOC emissions. The project will also include an effort to develop, test, and refine computer models of RC energy performance in California. Data from the field study will be used to validate the computer simulations and upgrade inputs to the model. Energy and cost-benefit projections will be made for different California climate zones.

February 2001

Progress was made in all planned activities. Draft DOE-2 input files were developed and supplied to CEC, however IDEC, variable speed fan and hydronic heating

functions are not completed. Preliminary mechanical drawings and specifications for the RC HVAC system including IDEC, hydronic heating, and ducting were completed. Plans for fabrication and testing of the hydronic heating system including the plenum/duct system and IDEC air handler and controls were completed and component parts were ordered. An IDEC unit was delivered to LBNL for this testing activity. A draft field monitoring plan and instrumentation specification for IEQ, thermal comfort, and energy monitoring was completed and equipment order lists were drafted. Contacts with school districts and their contract architects were strengthened, and numerous logistical plans related to siting were addressed. Issues included water, gas, and electricity supply, materials selection, internal cabinetry, and instrumentation placement. CEC was provided with a justification regarding the appropriateness of using natural gas for the heating component of the IDEC system.

Specimens of 18 standard and alternative interior materials have been obtained. These material specimens are being tested for emissions of formaldehyde and VOCs of concern in our small-scale environmental chamber facility. Approximately one-half of the tests have been completed. We anticipate that we will complete most of the remaining tests in March.

E. Airflow and Pollutant Dynamics in Buildings

Particle Deposition to Indoor Surfaces
Sponsor(s): DOE-CBNP, LLNL
Collaborator(s): U.C. Berkeley, Dept. of Civil and Environmental Engineering

Background

Inhalation exposure to airborne particles can have adverse health effects. One fate for particles in indoors is deposition onto surfaces. Clearly, this process alters the likelihood of human exposure, since a deposited particle cannot be inhaled unless re-suspended. Knowledge of the rates of particle deposition onto indoor surfaces and the factors governing those rates is therefore important.

February 2001

No work was performed on this project in February.

Particle Deposition in Ductwork
Sponsor(s): DOE-CBNP, LLNL
Collaborator(s): U.C. Berkeley Dept. of Civil and Environmental Engineering

Background

The effort under this part of the project is aimed at developing a computational predictive ability for dispersion of gases and aerosols in large indoor spaces. Such a predictive capability will allow development of exit strategies, as well as containment strategies for an unexpected pollutant release in an indoor large space. We are also

interested in obtaining an improved understanding of pollutant dispersion in large indoor spaces to reduce occupant exposures under a variety of scenarios.

February 2001

M Sippola has performed particle deposition experiments in his experimental duct apparatus for monodisperse particle sizes of 2.5, 3.7 and 5.0 µm particles and a duct Reynolds number of 53,000. Difficulties with the particle generation system have persisted and have slightly reduced data quality. Observed particle deposition in these experiments has been larger than deposition predicted by the two-fluid model for all duct surfaces (i.e., ceiling, wall and floor). Measured particle deposition for 2.5 µm particles in the new duct apparatus is the same as measured in the old duct apparatus.

Recent minor improvements to the experimental duct include installation of continuous temperature, relative humidity and pressure sensors and the improvement of the particle injection mechanism into the mixing box.

Particle Penetration through Building Cracks

Sponsor(s): DOE-CBNP, LLNL

Collaborator(s): U.C. Berkeley Dept. of Civil and Environmental Engineering

Background

The goal of the particle penetration through building cracks investigation is to explore the extent to which particles in infiltrating air remain airborn as the air passes through the building envelope. The work started with modeling, and now includes experiments to validate the predictions. We have finished the idealized crack experiments and will embark on realistic building cracks soon. These results are expected to help us gain insight on the protection of building shell might offer, especially for air leakage dominated buildings.

February 2001

D. Liu's effort in Feb. was devoted to analyzing the data sampled from the Fresno house study. Preliminary results indicated the measured particle penetration factors were in the range of 0.5-0.8. The phase change of ammonium nitrate particles were observed, and this phenomenon needs to be considered in the future when adjusting the calculation of particle penetration factors. Ozone penetration was estimated in the range of 0.6-1.0. The ozone deposition velocity was determined to be 0.2-0.4 cm/s, which agrees well with previous studies.

Multizone Simulation and Model Development

Sponsor(s): DOE-CBNP, LLNL

Collaborator(s): U.C. Berkeley Dept. of Civil and Environmental Engineering, Dept. of Architecture

Background

This task seeks to develop and implement models for pollutant transport in buildings. This includes coupling the COMIS multizone airflow program with the MIAQ4 aerosol dynamics model. The model development effort aims to improve our capabilities for predicting gas and aerosol transport in heterogeneous multi-room indoor environments. The models have two major applications: (1) as tools used directly to predict airflow and pollutant transport in buildings; and (2) as testbeds to check our understanding of the physical processes that explain experimental data on pollutant transport.

February 2001

L. Mora began comparing predictions from coarse-grid 2D CFD models against experimental data in mixed convection conditions. The case under study was carried out by J. Zhang from the Canadian National Research Council. In the experiment, flow in a 7.3x5.5x2.5-high room was found to be two-dimensional. The thermal excitation was imposed by a heated floor (constant floor temperature), while other walls are considered adiabatic. Air enters the room at 1.78 m/s (Re=6000) from the upper part of the left wall, and goes out at the opposite wall at 1.5 m high. Temperatures and velocities were measured at 205 locations with a thermocouple and a hot wire probe respectively. Predictions from a standard k-e CFD model, as well as from coarse-grid k-e CFD models, were found to be in satisfactory agreement with experimental data.

H. Li began assembling an experimental apparatus for testing the dynamic model of fan startup and shutdown transients in a duct system.

D. Lorenzetti distributed the second draft of a paper on the future of COMIS for review.

D. Lorenzetti helped fix a problem with the COMIS input files prepared by EnergyPlus for coupled thermal-airflow problems.

The LBNL Legal Department approved a license agreement for COMIS v.3.1.

Prototypical Building Characterization
Sponsor(s): DOE-CBNP
Collaborator(s): None

Background

This project's goal is to develop building management strategies to reduce occupant exposures to an unexpected release of a toxic aerosol or gas. The release could be indoors or in the building vicinity. Our approach is to develop prototypical model buildings that represent the general building stock and to use them to simulate hypothetical pollutant releases. The concentration predictions will help us understand how pollutants are expected to distribute in a building and how event-specific uncertainties might affect the generalizations. Rules-of-thumb response strategies will

be developed based on the model predictions. We are currently developing response strategies for commercial office buildings.

February 2001

M. Sohn, R. Sextro, and A. Gadgil have submitted a journal manuscript titled, "Responding to Sudden Pollutant Releases in Office Buildings: 1. Framework and Analysis Tools" to Indoor Air for journal publication.

M. Sohn has completed the second draft of a manuscript titled, "Rapidly Locating and Characterizing Pollutants in Buildings: An Application of Bayesian Data Analysis". The authors are M. Sohn, P. Reynolds, N. Singh, and A. Gadgil. The paper develops and demonstrates a Bayesian updating approach for quickly interpreting pollutant sensor data in buildings. The approach may also assist building managers place and operate sensors in buildings. In an illustrative demonstration, synthetic sensor measurements were successfully used to locate and describe a pollutant release in a five-room building. We expect to submit the manuscript to the Journal of the Air and Waste Management Association in March.

M. Sohn has written a proposal to implement our Bayesian updating algorithm in a real building. We plan to submit the proposal to Richard Wheeler at DOD.

Air Flow and Pollutant Dispersion in a Large Room
Sponsor(s): DOE-CBNP, LLNL
Collaborator(s): None

Background

We are using a combination of computational fluid dynamics (CFD) modeling and experimental work to advance CFD models for use in buildings and to help us to develop a simpler "lumped parameter" model for air flow and pollutant dispersion in a single, large room, *e.g.*, an auditorium, to incorporate into COMIS. This work also involves a collaboration with scientists in France who are developing CFD models.

February 2001

During the month of February, E. Finlayson and C. Lobscheid made progress with two isothermal mixing time models.

E. Finlayson began work on obtaining transient concentration profiles in the Atrium. These profile show the decay of the pollutant after a 5 minute continuous release is turned off. Inconsistencies in results obtained from different version of the CFD software have hampered this effort.

C. Lobscheid, a visiting scholar from Germany working on his Master's degree, continued to work on his model of a pervious experiment performed by Anushka Dresher as part of her Ph.D. dissertation. This model looks at mixing time as a function

of mechanical mixing. A velocity field was obtained for a coarse mesh and subsequent refinements were performed to obtain a grid independent solution.

Fischer received, revised, and returned page proofs for a manuscript on the Atrium facility experiments to the Journal of the Atmospheric Environment. Fischer also completed revisions describing the Atrium facility for inclusion in an LBNL report on the Interiors project authored by A. Gadgil. Last, Fischer wrote a description of experiments that could be performed to test the efficacy of using an air curtain to limit transport of pollutants from one section of a large room from another.

Price also received, revised, and returned page proofs for a manuscript on the recently developed "low third derivative" method of performing real-time computed tomography reconstructions of tracer gas concentrations, applied to the Atrium experiments. This paper will be published in the same issue as Fischer's. Price also created new figures for an LBNL report on the Interiors project, with Gadgil as lead author.

Price, Sohn, and Lorenzetti analyzed data from the experimental atrium, in an effort to define characteristic time-scales for mixing in the room (e.g., how long does it take for the room to reach its steady-state condition), and to quantify the extent to which the room does or does not become "fully mixed" at long times. For a continuous tracer-gas release at floor level, with continuous ventilation of the room, the tracer gas concentration in the breathing plane remains substantially non-uniform: even a long time after the start of the release, the concentration at some points is over twice as high as at other points.

Mathias Cehlin, a doctoral student of Mats Sandberg from University of Gavle in Sweden arrived for a study visit of 8 weeks to work with Airflow and Pollutant Transport Group regarding his interest in using computed tomography to map aerosol concentrations in indoor spaces.

The CEO and VP of R&E from Ion Systems visited researchers in Airflow and Pollutant Transport group to assess potential of conducting research at LBNL on dispersion of air ions in semiconductor fabrication facilities ("fabs").

Dr. Marc Abadie arrived for his 16 months of research service in lieu of military service in France. He started working on CFD applications to the combined heat and mass transfer problems related to infiltration through insulated walls with differentially heated surfaces.

F. Service to Professional and Governmental Organizations

ASHRAE
Sponsor(s): DOE-EE

Collaborator(s): none

Background
Bill Fisk serves on ASHRAE's Environmental Health Committee (EHC's), as chairman of the EHC's Research Subcommittee, and on ASHRAE's IAQ'2001 Organizing Committee.

February 2001
Another set of abstracts for the IAQ2001 meeting were reviewed.

Indoor Air 2002 Organizing Committee
Sponsor(s): DOE-EE, AIHA, and many other sponsors
Collaborator(s): U.C. Berkeley, California Department of Health Services

Background
The Indoor Air 'xx conference, held every three years, is the largest and most prestigious international indoor air quality conference. Hal Levin, Bill Nazaroff, Bill Fisk, Rich Sextro, and non-LBNL staff are serving on the organizing committee for the Indoor Air 2002 organizing committee, with Hal Levin serving as the Conference President. DOE contributed $30K during FY2000 to the organization of this conference. Support from a large number of sponsors is anticipated.

February 2001
Considerable effort was devoted to negotiations with the International Society for Indoor Air Quality and Climate (ISIAQ). As of the end of February, most issues had been resolved. Other activities included further upgrades to the conference email system, audiovisual planning, sponsorship planning, and initial work on the call for papers.

OUTSIDE CONTACTS

February 2001
Several Interiors Project members met with representatives from Ion Systems, a supplier of ionization equipment for cleanrooms, to discuss possible collaboration.

A four-page pamphlet of "advice for first responders to a chemical or biological release" was sent to the City of Berkeley fire chief for review.

Regular telephone conference calls are being held with the research team developing the Hypak unit, including staff of Davis Energy Group, Des Champs Laboratories, and AD Little. Conference call discussions were also held with the organizers of Indoor Air 2002.

INDOOR ENVIRONMENT DEPARTMENT

3. Healthy Buildings and Productivity Studies

W.J. Fisk
510-486-5910

A. Experimental Healthy Buildings and Productivity Research

Healthy Buildings Intervention Study
Sponsor(s): DOE-EE, NIOSH, EPA
Collaborator(s): NIOSH

Background
LBNL and NIOSH have conducted a blinded-controlled intervention study in an office building to evaluate the effects of enhanced particle filtration systems, improved surface cleaning, and air temperatures on health symptoms. The filtration intervention involved switching on a weekly basis between typical and high efficiency filters on two floors of an office building. On Thursday or Friday afternoon of each week, occupants reported their health symptom intensities for the current day. Extensive environmental measurements were performed throughout the study. After the seven-week filtration intervention study, a surface cleaning intervention, consisting of special intensive vacuuming of floors and chairs, was performed on one floor with the occupants of the second floor serving as the control group. A third "natural experiment" occurred throughout the study due to natural temporal variations in indoor air temperatures. A short paper on the filtration intervention was published in FY2000.

February 2001
We were notified by the editors of *Epidemiology* that they have sent our paper out for review.

Ventilation Rate Intervention Study
Sponsor(s): DOE-EE
Collaborator(s): Center for the Built Environment

Background
In this study, we are quantifying the relationships of worker performance in a call center with building ventilation rate and air temperature. Worker performance is being determined from the automatically-recorded telephone call data at three relatively constant outside-air ventilation rates, and also with the economizer system operating. The minimum ventilation rate corresponds to applicable code requirements. Periods of steady ventilation rates range from one week to one day. Indoor air temperatures and building occupancy fluctuate naturally. Temperatures, humidifies, carbon dioxide concentrations, and VOC concentrations are being monitored.

February 2001

Data files are being processed to obtain a format suitable for the statistical analyses. Also, we examined the occasional excursions (e.g., spikes) in the temperature data and confirmed that the cause was instrumentation problems.

B. Literature Reviews and Assessments

Association of HVAC Type and Features with SBS Symptoms
Sponsor(s): DOE-EE
Collaborator(s): Helsinki University of Technology

Background

Cross-sectional studies from around the world have investigated the relationship of HVAC system type in commercial buildings with occupant health symptoms. LBNL and the Helsinki University of Technology are collaborating on a critical review of the literature. This document will summarize the findings of studies that satisfy study quality criteria and review the evidence supporting or refuting the hypothesized explanations for the observed associations.

February 2001

We are awaiting comments from reviewers on the paper submitted at the end of January.

Health and Productivity Reviews
Sponsor(s): DOE-EE
Collaborator(s): None

Background

In this area of work, critical reviews are performed to assess the opportunities for health and economic gains from improvements in indoor environmental quality.

February 2001

All current work on these reviews has been completed. Bill Fisk agreed to present this work at a conference of the American Lung Association / American Thoracic Society to be held in May 2001.

IAQ and Health in Schools
Sponsor(s): DOE-EE
Collaborator(s): University of Minnesota

Background

In 1999, the IED, working with Bill Angel at the University on Minnesota, completed a report on a broad review of IAQ and associated health problems in schools. A

conference article based on this review was presented in FY1999. The FY2001 plans are to complete and submit a journal article based on this work.

February 2001
There was no activity on this topic during February.

C. Analyses of Data from the EPA BASE Study

VOCs and SBS Symptoms
Sponsor(s): DOE-EE
Collaborator(s): EPA developed the database for these analyses

Background
EPA has collected a large set of data from office buildings, including building characteristics, air pollutant concentrations, and SBS symptom prevalences. We have used statistical models to analyze data from the first set of buildings and learn about the associations of volatile organic compounds with symptoms. The analysis will now be extended, using the data from all 100 buildings.

February 2001
During February we completed data cleaning and processing of the demographic and symptom data in the BASE survey dataset. Progress was made on analyses of the VOC data to investigate possible groupings signifying VOC sources using principal component analyses. Preliminary regression analyses to identify associations between VOCs and SBS symptoms were conducted.

Carbon Dioxide and SBS Symptoms
Sponsor(s): DOE-EE
Collaborator(s): U.S. EPA

Background
For this task, we are using multivariate statistical models to analyze data from the EPA BASE study to investigate the association of indoor carbon dioxide concentrations with SBS symptom prevalences.

February 2001
We continued to prepare the 100 building data set for analyses, as described in the previous section on VOCs and SBS Symptoms. Preliminary regression analyses to identify associations between building CO_2 and SBS symptoms were conducted.

D. Service To Professional And Governmental Organizations

National Occupational Research Agenda

Sponsor(s): DOE-EE supports time of LBNL staff serving on the National Occupational research Agenda Indoor Environment Team.
Collaborator(s): Broad representation on Committee from government, universities, labor

Background
Bill Fisk is participating in the activities of the National Occupational Research Agenda (NORA) Indoor Environment Team. The objectives of this interdisciplinary team established by NIOSH are to develop a priority research agenda related to IAQ and health in non-industrial occupational buildings, and to foster partnerships and collaborations as needed to implement the research agenda. This multi-disciplinary team is developing a paper on the highest priority research needs related to IAQ and health in non-industrial occupational environments.

February 2001
Final revisions were made to the NORA document. The section on communicable respiratory illness was expanded and strengthened and the calculations of asthma costs relevant to the non-industrial indoor workforce were improved.

California IAQ Interagency Working Group
Sponsor(s): DOE-EE supports the participation of LBNL staff in these meetings
Collaborator(s): Broad representation from the sponsors and performers of IAQ research in California

Background
The California Interagency Working Group (CIAW) meets quarterly to maintain communication on IAQ activities in California. Mike Apte serves as LBNL's representative.

February 2001
No activity.

OUTSIDE CONTACTS

February 2001
Bill Fisk provided another set of comments to the committees developing environmental and energy credits for the Green Buildings Council LEEDs, Commercial Interiors effort.

INDOOR ENVIRONMENT DEPARTMENT

4. EXPOSURE AND RISK RESEARCH

T.E. McKone, W.J. Fisk, A.T. Hodgson, R.G. Sextro
486-6163

A. Environmental Tobacco Smoke Research

Further Characterization of Environmental Tobacco Smoke
Sponsor(s): California Tobacco-Related Disease Research Program
Collaborator(s): None

Background
In this project, led by Rich Sextro, laboratory and field research is being conducted to assess the usefulness of particle-bound components of ETS as tracers for exposure assessment studies.

February 2001
Work continued on the project final report and on a journal manuscript. A group of ETS samples collected during the ETS laboratory experiments was re-analyzed for tracers that included scopoletin.

Vapor-Phase Organics in Environmental Tobacco Smoke
Sponsor(s): California Tobacco-Related Disease Research Program
Collaborator(s): U.C. Berkeley Department of Environmental Engineering

Background
Brett Singer and Al Hodgson are working on this project with assistance from several undergraduate students in the U.C. Berkeley Environmental Engineering Department. The project focuses on quantifying human exposure to vapor-phase organic compounds in ETS under a range of realistic smoking patterns and ventilation rates. Special attention is being paid to sorption processes that can have a large impact on airborne concentrations of semi-volatile organic compounds (SVOCs; *e.g.*, nicotine) both during and long after active smoking periods.

February 2001
We completed the long-term experiment to measure vapor-phase ETS concentrations in a furnished chamber with daily smoking. The VOC samples from this experiment were analyzed for a list of target compounds.

B. Performance of Smoking Rooms

Sponsor(s): California Tobacco-Related Disease Research Program
Collaborator(s): California Department of Health Services

Background

The IED and the California Department of Health Services (CDHS) are studying the performance of smoking rooms. Laboratory studies will assess the rate of ETS leakage from a smoking room to the adjoining space as a function of smoking room physical characteristics, door usage, and temperature and pressure differences. A mathematical model of smoking room performance will be developed and model predictions will be compared with measured data. A final phase of the project will assess the accuracy of the model in predicting the performance of smoking rooms located in a small number of office buildings.

February 2001

Measurements of environmental tobacco smoke (ETS) leakage from a smoking room continued. An experiment was performed in which the smoking room was operated at a large negative pressure (-10 Pa). This test yielded the best smoking room exhaust efficiency and lowest non-smoker exposure thus far. A duplicate experiment was performed and showed that our results are repeatable. The test chambers were altered for our next set of experiments, which address leakage of ETS through the smoking room's ceiling tiles. If non-smoking areas share the same ceiling plenum as the smoking room, ETS may be recirculated and supplied into these areas. In a preliminary test, the ceiling plenum was operated at a pressure of 0.8 Pa below that of the smoking room. Roughly half of the ETS ended up in the ceiling plenum instead of the smoking room exhaust. Equations were developed to express the smoking room exhaust efficiency and non-smoker exposure ratio as functions of the various leakage sources. Maintenance was required for the smoking machine valves, a thermistor, and the inlet filters to the GC, all of which had become seriously degraded by exposure to ETS.

C. The California Exposure Modeling Research Center

A Multi-Domain Framework for Integrating Models and Measurements of Multimedia Environmental Contaminants

Sponsor(s): U.S. EPA National Exposure Research Laboratory

Collaborator(s): U.C. Berkeley, Stanford University

Background

Tom McKone, Deborah Bennett, Neil Klepeis, Randy Maddalena, William Riley, and Agnes Bodnar are working on this project at LBNL; Wayne Ott and Paul Switzer are working on this project at Stanford University; and William Nazaroff, Katharine Hammond, and Michael Tarter participate through U.C. Berkeley.

The goal of this project is to develop and apply models to improve the process of exposure assessment in two ways. First is to provide a more complete picture of how humans are exposed to a number of important pollutants. Second is to determine the level of precision that is feasible for quantifying human exposure to these pollutants.

These efforts are being organized around two research components: (1) an indoor/outdoor model for total human exposure to particulate matter (PM); and (2) development and evaluation of source-to-dose models for persistent pollutants. These two components include a number of research areas.

February 2001

R. Maddalena and D. Bennett developed a revised work plan for evaluating the EPA Stochastic Human Exposure and Dose Simulation (SHEDS) model – a fully probabilistic exposure model. Maddalena installed SHEDS at LBNL where we have spent time getting familiar with the model.

W. Ott, who is working on this project through a sub-grant at Stanford is preparing an "Inventory of Indoor Particulate Source Strengths", based on several dozen particle measurement experiments conducted in California homes. This source strength inventory includes common indoor exposure events such as smoking different brands of cigarettes, smoking cigars, cooking a kitchen dinner for two of blackened catfish, making toast, frying a hamburger, preparing steak, burning popcorn, and accidentally burning an English Muffin. For each experiment, the particle mass source strength has been calculated using piece-wise continuous exponential solutions to the mass balance equation and a particle decay rate parameter has been calculated. Indoor emissions range from 6 mg for toasting whole wheat bread slightly brown to 257 mg for cooking a blackened catfish dinner for two. By comparison, smoking a single filter cigarette generated 15-17 mg of PM-3.5 particle mass emissions and smoking a cigar generated 32-88 mg, depending on the brand of cigar smoked. These estimated indoor source strengths are intended for use in mathematical exposure models, such as EPA's SHEDS particle model, that combine human activity patterns with micro environmental concentrations.

The paper "Indoor Particulate Matter of Outdoor Origin: The Importance of Size-Dependent Removal Mechanisms" by W. Riley, T. McKone, A. Lai, and W. Nazaroff was submitted to the journal *Environmental Science and Technology*. After the LBNL internal review process produced a set of review comments, W. Riley addressed the comments and prepared a final manuscript. As a result of the review Riley calculated the potential impact of changing particle penetration on overall results. For typical crack sizes, using the penetration theory of Liu and Nazaroff, the impact on PM2.5 and PM10 was less than 5%.

M. Sohn and T. McKone continued work on Bayesian approaches for calibrating physiologically-based pharmacokinetic (PBPK) models. M. Sohn is reviewing the human pharmacokinetic and exposure modeling literature to learn how biomarker data are used to reconstruct exposures and source events. To demonstrate our tools for analyzing biomarker data, M. Sohn and T. McKone are building simple computer models of physiologically-based human pharmacokinetics. M. Sohn is programming the computer models in the FORTRAN language so we can implement fast solution

algorithms to solve the ordinary differential equations. This is important for our exposure reconstruction modeling and uncertainty analyses. The model uncertainties and variability are so large that several thousand computer simulations will be needed. M. Sohn and T. McKone are reviewing the literature to select an appropriate range of chemical properties for an illustrative analyses.

W. Riley and T. McKone continued work on a dermal uptake model for short contact times. Their analysis of the rat malathion data supplied us by EPA Las Vegas disclosed that this data cannot be used to calibrate/test the short-term dermal exposure model. Samples were not taken early enough in the experiment, and the skin had essentially reached steady state by the time the measurements were started.

N. Klepeis worked on a journal manuscript that characterizes size-resolved particle emissions from cigars and cigarettes. The optimization of emissions and deposition velocity was carried out for 8 chamber experiments using the MIAQ model. In order to establish the sensitivity/uncertainty of parameters used in the optimization procedure, four different courses of optimization were performed. These courses were applied at 60 min and 480 min time periods (after the source was extinguished) and for cases where we included and excluded coagulation effects.

D. Bennett continued work on an indoor fugacity (chemical partitioning) model. In February, she worked on determining transfer factors between compartments. Particular emphasis was on transfer factors for floors, walls, and carpets. She also completed the mass balance for the multi-compartment house system in the form of an Excel spreadsheet that tracks all of the inputs and the compartment volumes and mass transfer coefficients.

A. Bodnar continued collecting data on source characterization of PAH emissions to the San Francisco Bay Area air shed. These data are being use to relate the emissions of PAH's with potential inhalation and ingestion exposures to the Bay Area population. With assistance from R. Maddalena, she continued evaluation of plant uptake data from UC Berkeley exposure chambers.

P. Switzer and W. Ott of Stanford have prepared letters to the editor of the *Journal of the Air and Waste Management Association* (JAWMA) discussing scientific methodology aspects of papers recently published in JAWMA and dealing with exposure modeling of particles in indoor microenvironments. Their letters have been accepted for publication in the March 2001 issue of JAWMA.

W. Riley together with a student from W. Nazaroff's laboratory are characterizing concentrations and emission rates of CO and Benzene in the LA basin. This is the first stage of an effort to assess the distribution of personal exposures to these substances in this region.

D. Total Risk Integrated Methodology (TRIM) Project

TRIM.FaTE Project
Sponsor(s): U.S. EPA Office of Air Quality, Planning and Standards
Collaborator(s): Oak Ridge National Laboratory, University of Tennessee, ICF Consulting

Background

Randy Maddalena, Tom McKone, Deborah Bennett, and Agnes Bodnar are working on this project. The Total Risk Integrated Methodology (TRIM) is an EPA project to develop models and data for assessing the multimedia residual health and ecological risk from pollutants released to air sheds. The LBNL team is working on two components of the TRIM project: (1) testing, evaluation, and validation of the TRIM.FaTE module; and (2) development of the TRIM.Expo multimedia, multipathway exposure model.

February 2001

R. Maddalena, D. Bennett, and T. McKone continued work on the TRIM.FaTE evaluation report. R. Maddalena reviewed and revised two chapter sections related to the vegetation module. D. Bennett responded to review comments on the several sections of the evaluation report she had written.

R. Maddalena, T. McKone and D. Bennett participated in a detailed audit of the algorithms used in the TRIM fate model. They compared the algorithms and parameters in the model code to those reported in the TRIM technical support document. R. Maddalena reviewed the vegetation algorithms, T. McKone and D. Bennett reviewed soil and ground water algorithms.

R. Maddalena, D. Bennett, and T. McKone participated in three TRIM conference calls and responded to several e-mail questions about the model-evaluation process.

E. Criteria for Evaluation and Development of Probability Density Functions for a Set of Human Exposure Factors

Exposure Factor Distributions
Sponsor(s): U.S. EPA Office of Emergency and Remedial Response
Collaborator(s): None

Background

Randy Maddalena, Tom McKone, and Agnes Bodnar are working on this project. The Office of Emergency and Remedial Response (OERR) plays a lead role in developing national guidance and planning future activities that support the EPA Superfund Program. The purpose of this project is to develop for OERR methods for scoring the quality, relevance, and reliability of probability density functions.

February 2001

R. Maddalena and T. McKone participated in a conference call with EPA project manager S. Chang to review the current draft report and identify possible areas for continued research. We agreed that the current year's report would cover two areas; (1) our framework for evaluating probabilistic risk assessments and (2) development of probability distributions for body weight and exposure duration. We also agreed to submit a 2-page proposal describing how we could address the problem of variance inflation (lack of relevance) caused by using very small samples (i.e., 2 points) per individual to calculate the distribution of population means for exposure factors. The relevant case study for this issue is drinking water consumption where a mean value for individuals is calculated from two observations and the resulting individual mean values are used to construct a distribution for the population mean.

F. Inter-Individual Differences in Metabolism of Carcinogens as a Risk Factor for Breast Cancer

Sponsor(s): U.S. Department of the Army
Collaborator(s): None

Background

The purpose of this project, led by Regine Goth-Goldstein, is to test for possible genetic factors that contribute to breast cancer risk, such as inter-individual variation in the level of enzymes that activate or detoxify environmental carcinogens. Variation in the level and activity of these enzymes can be due to mutations in the DNA sequences of the genes coding for these enzymes (genetic polymorphism) or to modification of gene expression by genetic and environmental factors. We have focused on the cytochrome P450 enzymes CYP1A1 and CYP1B1, both involved in activation of polycyclic aromatic hydrocarbons (PAHs). We are investigating whether the level of expression of these genes in breast tissue represents a risk factor for breast cancer.

February 2001

There were no new research results during February.

G. Indoor Bio-aerosol Detection and Quantification by PCR

Sponsor(s): Laboratory Directed Research and Development (LDRD) Program
Collaborator(s): None

Background

The goal of this project is to develop and demonstrate a quantitative polymerase chain reaction (PCR) assay for rhinovirus, the virus that causes about half of common colds, and to use this assay to characterize the size distribution of human-produced droplet nuclei containing rhinovirus. Bill Fisk, Regine Goth-Goldstein and Marion Russell are working on this project.

January and February 2001

We conducted genetic sequence analysis of rhinovirus and enterovirus families in order to design a quantitative PCR assay. Primers were chosen to target the 5' untranslated region of the rhinovirus genome since this region has been shown to have a high degree of genetic homology. These primers will be specific for rhinovirus and will not detect the genetically similar enterovirus. Rhinovirus type 89, available from ATCC is being used to obtain a standard for PCR-quantitation. Total RNA was isolated from rhinovirus 89 and reverse transcribed. Two rhinovirus fragments could be detected in the isolate by PCR using the rhinovirus-specific primers: a 425 base pair fragment and a 203 base pair sequence contained in the 425 bp fragment. The 425 bp fragment is being isolated and will be cloned to be used as a standard. The internal fragment will be used for identification of rhinovirus in human mucous samples. The advantage of this assay is that no sub typing is needed to distinguish rhinovirus from enterovirus. The primers for this internal fragment will detect more than 90% of rhinovirus strains, but a few enterovirus-like rhinovirus strains (87, 14, 37, and 72) will not be detected.

H. Measurement of Semi-Volatile Organics in Ambient Air

Sponsor(s): U.S. EPA, EPRI, University of Texas, Washington State University
Collaborator(s): U.S. EPA, EPRI, University of Texas, Washington State University, Environment Canada, University of Washington, U.C. Berkeley, U.C. Los Angeles, Desert Research Institute, Restek Corporation, URG Corporation

Background

The objective of this project, led by Lara Gundel, is the development, validation, and application of new measurement methods for the accurate determination of semi-volatile organic pollutants in ambient air. Such species partition between the gas and particle phases in ways that complicate measurement and apportionment efforts. LBNL is contributing to several multi-investigator studies whose overall goal is the characterization of carbonaceous particles across the U.S.

February 2001

Work continued on the final report to the U.S. EPA and on several journal articles that present the results of recent validation studies for diffusion-based sampling methods for semi-volatile and particulate organic pollutants. We continued to participate in the characterization of particulate phase semi-volatile organic compounds in the Pacific Northwest. Diffusion-based indoor sampling was initiated in Seattle to assess the contribution of semi-volatile organic compounds to the large indoor sampling artifacts that are being observed in several cities. In collaboration with U.S. EPA, we developed and validated sample preparation methods for use in the Texas Air Quality Study 2000.

I. Traffic Study

Sponsor(s): California EPA, Office of Environmental Health Hazard Assessment (OEHHA)
Collaborator(s): OEHHA

Background

OEHHA is conducting a study of respiratory health of school children (4th and 5th grades) that reside and attend school in several California East Bay Area communities. OEHHA is attempting to determine whether the children's total exposures to traffic-related emissions are related to respiratory symptoms. LBNL is assisting OEHHA with the environmental measurements for the study. Our primary objectives are to identify markers for gasoline and diesel powered vehicle-related pollution and to make field measurements of these gaseous and particulate pollutants both indoors and outdoors at a set of East Bay Elementary schools throughout the remainder of the school year. Brett Singer, Tosh Hotchi and Al Hodgson are conducting this study.

February 2001

We completed the sampling plan and schedule for the project in collaboration with the OEHHA project managers. We purchased all of the sampling system components and manufactured several custom components including equipment enclosures, battery power sources, and filter masks to concentrate the PM and black carbon samples. We wrote protocols for the collection and analysis of all samples. Additional visits were made to the schools to establish contacts with school personnel and to identify locations for the placement of the equipment enclosures. Intercomparison studies of CO monitors and of the PM_{10}, $PM_{2.5}$, black carbon sampling equipment were conducted. CO Monitors and sampling pumps were calibrated.

J. Building Characteristics that Influence Indoor Exposures to Outdoor Aerosols

Sponsor(s): EPA National Exposure Research Laboratory
Collaborators: None

Background

The goal of this project is to identify and characterize data sets for building characteristics that impact indoor concentrations of particles of outdoor origin. Concentrations of ambient particles indoors depend upon the fraction of particles that penetrate through the building shell or are transported via the HVAC system and the loss mechanisms that occur indoors, such as deposition.

February 2001

T. McKone prepared a report for W. Mitchell, the EPA contract monitor. In this report McKone provided an update on the status of the project including the revised outline of the report and detailed annotations on the current status of each section. McKone then called together the full group of project collaborators to develop and maintain a schedule for completing the Building Characteristics report.

K. Other Efforts

February 2001

Regine Goth-Goldstein and Marion Russell attended a meeting on "Human xenobiotic metabolism" organized by GETA (Genetic and Environmental Toxicology Association of Northern California). R. Goth-Goldstein also attended a meeting of the American Association for Cancer research on "Genetic Modifiers of Cancer Susceptibility: Lessons from Human Population Studies and Mouse Models" that was held at Incline Village, NV from February 25 through March 1.

Lara Gundel and staff began the determination of inorganic ionic species in particles collected in Fresno from October 2000 through January 2001.

During February the Exposure and Risk Analysis Group held two group meetings. On February 20 - K.C. Jones (a visiting scientist from Lancaster University in the UK) discussed the global distribution of persistent pollutants with our group. On February 27 - Neil Klepeis discussed his work on secondary exposure to ETS, activity pattern simulation, and generalized software for exposure modeling.

On February 18, R. Maddalena chaired a Symposium titled "Pollutants without Borders: Tracking the Long-Range Impact of Persistent Chemicals" at the Annual Meeting of the American Association for the Advancement of Science. This session was organized by Maddalena and T. McKone of LBNL and D. Mackay of Trent University, Canada. During the symposium, T. McKone presented a paper titled "Including Source-to-Effect Relationships in the Long-Range-Transport Framework."

On February 26, R. Maddalena made a representation to the monthly IED Principal Investigators Meeting on the use of default distributions in probabilistic risk assessment, a topic that he is researching with funding from the EPA Superfund Program.

OUTSIDE CONTACTS

February 2001

Lara Gundel met with colleagues at the winter meeting of the Board of Directors of the American Association for Aerosol Research. She participated in planning an inter-laboratory characterization of ambient particulate matter with Joellen Lewtas of the U.S. EPA.

On February 20, the Exposure and Risk Analysis Group hosted a visit from Dr. Kevin Jones of Lancaster University in the United Kingdom. Dr. Jones spent the day meeting with the group to discuss his and our research on persistent pollutants and the uptake of pollutants from soil and air into vegetation. Dr. Jones presented a Division seminar

on experimental evidence for the existence of and mechanisms for long-range pollutant transport.

Kathrin Fenner, who is visiting LBNL from the Swiss Federal Institute of Technology in Zurich continued her collaborative work with R. Maddalena, D. Bennett, and T. McKone on methods for addressing uncertainty in multimedia fate models. In February she worked on the problem of fitting observations of chemical degradation that could be interpreted as either the half life or as degradation rate constants (proportional to 1/[half-life]). The issue is how this interpretation impacts the fit of the data to a probability distribution and stochastic outcome of a fate model. Kathrin found the results invariant to the data interpretation.

INDOOR ENVIRONMENT DEPARTMENT

5. International Energy and Environmental Activities

A.J. Gadgil
510- 486-4651

A. UVWaterworks
Sponsor(s): DOE-EE
Collaborator(s): None

Background
The UVWaterworks system uses ultraviolet (UV) light to treat water contaminated with bacteria, viruses, and Cryptosporidium. The technology, developed at the Lawrence Berkeley National Laboratory, has been licensed to WaterHealth International (http://www.waterhealth.com). DOE has supported limited field trials of the technology in South Africa, as part of DOE's participation in the SA-US-BiNational Commission.

February 2001
India earthquake relief efforts made some slow progress in planning to send some UVW units to the quake victims. There is also some interest from some non-profit organizations in using UVW units in Bangladesh to treat surface water, as a way to circumvent the ground-water laced with arsenic that is poisoning between 40 to 70 million people in that country.

We continue to receive reports of testing the second and third field site units in South Africa by e-mail.

B. Other Efforts

None.

INDOOR ENVIRONMENT DEPARTMENT

6. Program Support and Administration

W.J. Fisk
510-486-5910

February 2001
IED staff completed FWPs and FPPs for DOE.

IED PIs met on February 26 and started to develop ideas for Laboratory Directed Research and Development (LDRD) Proposals. They were also briefed by staff of the sponsored projects office regarding the last minute submission of proposals.

IED hosted seminars by two visitors. Aino Nevalainen of the National Public Health Institute of Finland described her research on moisture and mold problems. Klaus Willeke of the University of Cincinnati described his research on advanced sampling technologies for bio-aerosols.

7. STATUS OF FY2001 DELIVERABLES FOR DOE/OBT

Deliverable or Milestone	Due Date	Status
TASK 1. ENERGY PERFORMANCE OF BUILDINGS		
Completion of First Public Review of Standard 62.2	11/00	Completed
Preliminary Analysis of Air Leakage Database	1/01	Completed
Status report on Energy Efficiency Ventilation Demonstration Case Study	3/01	
Recommendations regarding future participation of the US in AIVC	5/01	
Second Public Review of Standard 62.2	7/01	
Technical paper on infiltration heat recovery	9/01	
TASK 3. VENTILATION AND IAQ CONTROL TECHNOLOGIES		
Submit paper on comparative assessment of particle air cleaning	11/00	Delayed
Submit journal paper on a new approach for measuring the concentrations of VOCs in vinyl flooring	12/00	Completed
Submit journal paper on validation of a single-layer model to predict emissions rates of VOCs from vinyl flooring	3/01	
Paper on literature review and product and practice survey for measurement and control of outside air supply by HVAC systems	7/01	
Conference paper on methodology for establishing health- and comfort-based criteria for VOC emissions from building materials	9/01	
Paper on task ventilation optimization studies	9/01	
TASK 4. HEALTH BUILDINGS AND PRODUCTIVITY RESEARCH		
Submit paper on IAQ, ventilation, and health in schools	10/00	Completed
Complete data collection in productivity field study	12/00	Completed
Article for ASHRAE Journal or equivalent on ventilation rates and health	6/01	
Paper on analyses of BASE Study data from 100 buildings	7/01	
Draft paper on productivity field study	8/01	
Expanded article on association of symptoms with high-efficiency filtration, temperature, and humidity is accepted for publication	9/01	Submitted
Submit journal article on HVAC and health	9/01	Submitted
TASK 5. ENERGY EFFICIENT FUME HOODS		
Technical paper on design development and test results of high-performance fume hood	6/01	
Article on high-performance fume hood for professional publication	12/01	
Task 6. IAQ Assessments of New Energy-Efficient Housing		
Submit journal paper on sources of formaldehyde and other VOCs in a new manufactured house	9/01	